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Mail Stop Non-fee Amendment
Commissioner for Patents
P.O. Box 1450
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Re: Inventor: Robert Louis Giuliani
Application no. 10/643274
Filing date: 08/18/2003
Title: Interchangeable 2-stroke or 4-stroke High Torque Power Engine
CIP of application no.10/252,927 filing date 09/24/2002
Art Unit: 3748
Confirmation no. 4067

INTRODUCTORY COMMENTS

The attached "Amendments to the Specification" of the above application no.10/643274 are on the following sheets. The section to be amended is on sheets 2,3. The amendments for it are on sheets 4-7. The REMARKS are on sheet 8.

I've tried to make this amendment comply with "Waiver of 37 CFR 1.121" "Revised Amendment Format" that I took from the internet. If it does not agree with "Waiver of 37 CFR 1.121" "Revised Amendment Format", please let me know where my mistakes are and I will correct them. I can be reached at my above address, email or phone no. If by phone, the best time to reach me is 7:30AM – 8:30AM, Hawaii time. I think that the East Coast is 5 hours ahead of Hawaii time.

There are no Amendments to the Claims.

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~~Underlying Mathematics.~~

~~The discussion below references the following equations by their definitions, e.g. F lbf. Some Complete equations are also included in the discussion.~~

~~Definitions:~~

~~**1 BTU** = 778 ft-lbf~~

~~1 hp = 550 ft-lbf/sec~~

~~$2\pi r'$ = length of 1-way clutch rim at connecting rod contact. (ft).~~

~~**F** – actual mean combustion force/piston (lbf)~~

~~**F′** – most efficient mean combustion pressure/piston (lbf/in^2)~~

~~**Fr** – fuel flow rate (lbm/sec.)~~

~~**hp** – shaft horsepower (1 hp = 550 ft-lbf/sec)~~

~~**Lo** – Power losses (fraction of hp)~~

~~**n** – total number of pistons. 2,4,6, ...~~

~~**n/2** – 2 stroke. Number of equally spaced overlapping pistons cycling through the power stroke.~~

~~**n^2/2** – 2-stroke shaft power. (ft-lbf/sec).~~

~~**n/4** – 4-stroke. Number of equally spaced overlapping pistons cycling through the power stroke.~~

~~**n^2/4** – 4-stroke shaft power. (ft-lbf/sec) See FIG 6.~~

~~**Qc** – fuel's energy density. (BTU/lbm).~~

~~**r′** – 1-way clutch radius at connecting rod contact. (ft). See FIG 15.~~

~~**ra** – radius of cylinder. (in)~~

~~**Rv** – power shaft's rotation rate. (rpm)~~

~~**Sp** – shaft power + losses. (ft-lbf/sec.)~~

~~**T** – Torque. (lbf-ft)~~

~~**Vp** – piston's velocity. (ft/sec)~~

~~Equations:~~

~~**$Vp = (2\pi)(r')(Rv)/(60)$** Piston's speed and the 1-way clutch rim speed are equal at contact..~~

~~**$r' = 60(Vp)/2\pi(Rv) = 30(Vp)/\pi(Rv)$** r′ is central to this engine's design and operation..~~

~~**$Rv = 30(Vp)/\pi r'$**~~

~~**$Sp = 550(hp)(1 + Lo)$**~~

~~**$Fr = (Sp)/(778Qc)$**~~

~~**$Fr = (F)(n^2)(Vp)/[2(778)(Qc)]$**~~

~~**$F = 2Sp/(n^2Vp)$**~~

~~**$T = F(r')$**~~

$\cancel{F' = F/(\pi r_b^2)}$

$\cancel{r_b^2 = F/(\pi F')}$

$\cancel{\text{bore} = 2\sqrt{F/(\pi F')}}$

~~The advantage of overlap is evident in the next two examples that compare the number of cylinders in this smaller engine with the number of cylinders in a crank engine of equal power. The examples also show the power advantage of this engine's overlapping 2-stroke over its 4-stroke.~~

~~1. Example of this 2-stroke engine with **n** cyls. vs the number of crank engine cyls. of equal power:~~

~~Let **n** = 6 then~~ $\cancel{n^2/2 = 18}$ ~~crank engine cyls.~~

~~2. Example of this 4-stroke engine with **n** cyls. vs the number of crank engine cyls of equal power:~~

~~Let **n** = 8 (two banks of 4 pistons each in FIG 8) then~~ $\cancel{n^2/4 = 16}$ ~~crank engine cyls.~~

~~The deactivation feature also makes a 4-Strokebank combined with 2-Stroke pairs advantageous.~~

First, consider the benefit of overlapping power pistons on the power stroke e.g., a 2-stroke, 6 cyl engine with a 9" piston stroke would simultaneously have the 1st piston 6" after tdc, the 2nd piston 3" after tdc and the 3rd piston igniting at tdc. The 6 pistons continuously cycle through their power strokes in this sequence. The power added by the 3rd piston is reduced by the combined remaining power of the 1st and 2nd pistons resulting in fuel savings and smooth power shaft rotation.

Underlying Mathematics.

Definitions:

1 BTU = 778 ft-lbf

1 hp = 550 ft-lbf/sec.

2πr′ = length of 1-way clutch rim at connecting rod contact. (ft)

bore – cylinder diameter. (in.)

Cp – cylinder pressure calculated from known bore size. (psi)

F – combustion force per piston. (lbf)

F′ – estimated combustion pressure per piston. Used to find the bore size. (psi)

Fr – fuel flow rate (lbm/sec)

hp – shaft horsepower.

k = 2 or 4 (k = 2 for a 2-stroke. k = 4 for a 4-stroke.)

Lo – power losses (fraction of hp)

n – number of active pistons. 2,4,6,8, …

n/k – number of overlapping pistons cycling through the power stroke.

Qc – fuel's energy density. (BTU/lbm)

r′ – 1-way clutch radius at connecting rod contact. (ft)

r – radius of cylinder. (in)

Rv – power shaft's rotation rate. (rpm)

Sp – shaft power + losses. (ft-lbf/sec)

T – torque per piston. (lbf-ft)

T′ – total shaft torque. (lbf-ft)

Vp – piston velocity. (ft/sec)

Equations:

Vp = π(r′)(Rv)/(30) Piston rod's speed and the 1-way clutch rim speed are equal at contact.

r′ = 30(Vp)/π(Rv) **r′,Vp, Rv** are central to this engine's design and operation.

$Rv = 30(Vp)/(\pi r')$

$F = 550hp(k)/(nVp)$

$F = 16500(hp)(k)/\pi(n)(Rv)(r')$

$T = F(r')$

$T' = nT/k$

$F' = F/[\pi(r^2)]$

$r^2 = F/(\pi F')$

$bore = 2[F/(\pi F')]^{.5}$

$Cp = 4F/(\pi bore^2)$

$F = \pi F'(bore^2)/4$

$Sp = 550hp(1+Lo)$

$Fr = (Sp)/(778Qc)$

$Fr = (F)(n)(Vp)/[k(778Qc)]$

Examples that find preliminary information to any size engine with a hand calculator. (800 psi is estimated where used.)

Example: 6 cylinder, 2-stroke, 700 hp.

1. Let: **hp** = 700; **Vp** = 15 ft/sec; **F′** = 800 psi; **n** = 6; **k** = 2; **r′** = .75 ft = 9 in.

F = 2(700)(550)/[(6)(15)] = 8556 lbf

Rv = 30(15)/(.75π) = 191 rpm

bore = $2[(8556/800\pi)]^{.5}$ = 3.690 in.

T = 8556(.75) = 6417 lbf-ft

T′ = 6(6417)/(2) = 19251 lbf-ft

Example: 6 cylinder, 2-stroke, 1200 hp.

2. Let: **hp** = 1200; **Vp** = 22 ft/sec; **n** = 6; **k** = 2; **r′** = .75 ft. = 9 in. (Compare results to 1.)

F = 2(1200)(550)/[(6)(22)] = 10000 lbf

Rv = 30(22)/(.75π) = 280 rpm

bore = 3.690 in. (from example 1.)

Cp = $4(10000)/[\pi(3.690^2)]$ = 935 psi (Compare to **F′** = 800 psi in 1.)

T = 10000(.75) = 7500 lbf-ft

$\mathbb{T}' = 6(7500)/2 = 22500$ lbf-ft

Example: 8 cylinder, 4-stroke (2 banks of 4 cyls. each) 1200 hp engine. See FIG 6.

3. Let: $\mathbb{hp} = 1200$; $\mathbb{F}' = 800$ psi; $\mathbb{n} = 8$; $\mathbb{k} = 4$; $\mathbb{Rv} = 115$ rpm; $\mathbb{r}' = 1.25$ ft. (1 cyl. per 1-way clutch requiring eight 1-way clutches. 50% overlap.)

$\mathbb{Vp} = 1.25\pi(115)/30 = 15.05$ ft/sec.

$\mathbb{F} = 4(550)(1200)/[(8)(15.05)] = 21927$ lbf.

bore $= 2[(21927/800\pi)]^{.5} = 5.907$ in. (Compare to example 3.)

$\mathbb{T} = 21927(1.25) = 27409$ lbf-ft

$\mathbb{T}' = 8(27409)/4 = 54818$ lbf-ft.

Example: 4 cylinder, 4-stroke 200 hp automobile engine. See FIG 6

4. Let: $\mathbb{hp} = 200$; $\mathbb{F}' = 800$ psi; $\mathbb{n} = 4$; $\mathbb{k} = 4$; $\mathbb{Vp} = 15$ ft/sec; **r'** $= .5$ ft $= 6$ in. (2 cyls. per 1-way clutch requiring two 1-way clutches. No power stroke overlap).

$\mathbb{F} = 200(550)(4)/[(4)(15)] = 7333$ lbf.

$\mathbb{Rv} = 30(15)/(.5\pi)$ 286 rpm.

bore $= 2[(7333/800\pi)]^{.5} = 3.416$ in.

$\mathbb{T} = 7333(.5) = 3667$ lbf-ft.

$\mathbb{T}' = 4(7333)/4 = 7333$ lbf-ft

Example: 8 cylinder, 2-stroke, 8,000 hp large marine engine.

5. Let: $\mathbb{hp} = 8000$; $\mathbb{F}' = 800$ psi; $\mathbb{n} = 8$; $\mathbb{k} = 2$; $\mathbb{Vp} = 28$ ft/sec; $\mathbb{Rv} = 120$ rpm. (1 cyl. per 1-way clutch requiring eight 1-way clutches. 14" piston stroke. 75% power stroke overlap.)

$\mathbb{F} = 2(550)(8000)/[(8)(28)] = 39286$ lbf

$\mathbb{r}' = 30(28)/(120\pi) = 2.228$ ft. The transmitting units 89 (FIGs 7,8) could be carried by a short outer race 5 with a single spoke 35 to reduce inertia.

bore $= 2[(39286/800\pi)]^{.5} = 7.907$ in.

$\mathbb{T} = 39286(2.228) = 87529$ lbf-ft

$\mathbb{T}' = 8(39286)/2 = 157144$ lbf-ft.

Next, comparing the number of cylinders in this smaller engine to the number of cylinders in an equal powered crank engine.

1. For a 2-stroke engine with **n** cyls., let **n** = 6 then $\mathbf{n^2/2}$ = 18 crank engine cyls.

2. For a 4-stroke engine with **n** cyls., let **n** = 8 (two banks of 4 pistons each in FIG 6), then $\mathbf{n^2/4}$ = 16 crank engine cyls.